Overview of Environmental and Hydrogeologic Conditions at Sitka, Alaska

U.S. GEOLOGICAL SURVEY

Open-File Report 95-345

Prepared in cooperation with the

FEDERAL AVIATION ADMINISTRATION

Overview of Environmental and Hydrogeologic Conditions at Sitka, Alaska

By Eppie V. Hogan

U.S. GEOLOGICAL SURVEY

Open-File Report 95-345

Prepared in cooperation with the

FEDERAL AVIATION ADMINISTRATION

Anchorage, Alaska
1995

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey
4230 University Drive, Suite 201
Anchorage, AK 99508-4664

Copies of this report may be purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Federal Center
Denver, CO 80225-0425

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To obtain
centimeter (cm)	0.3937	inch
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
square kilometer (km^2)	0.3861	square mile
liter (L)	0.2642	gallon
liter per day (L/d)	0.2642	gallon per day
cubic meter per second (m^3/s)	35.31	cubic foot per second
cubic meter per second per square kilometer ($(m^3/s)/km^2$)	91.4	cubic foot per second per square mile

In this report, temperature is reported in degrees Celsius (° C), which can be converted to degrees Fahrenheit (F) by the following equation:

$$F = 1.8\,(C) + 32$$

Chemical concentration and water temperature are given only in metric units. Chemical concentration in water is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the solute mass per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter.

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—A geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Overview of Environmental and Hydrogeologic Conditions at Sitka, Alaska

By Eppie V. Hogan

ABSTRACT

The city of Sitka is in southeast Alaska on Baranof Island, about 150 kilometers southwest of Juneau and about 950 kilometers southeast of Anchorage. The Federal Aviation Administration owns or operates airway support facilities on Japonski Island, about 0.8 kilometers west of Sitka. They wish to consider environmental and hydrogeologic conditions when evaluating options for environmental compliance and remediation at these facilities. The area lies in the maritime climate zone and has cool summers and mild winters. Vegetation consists primarily of coastal western hemlock-Sitka spruce forest. The bedrock in the Sitka area consists of graywacke, slate, and conglomerate of late Jurassic to early Cretaceous age. Surficial deposits of Quaternary age—drift, volcanic ash, muskeg, elevated delta and shore deposits, alluvial deposits, modern beach deposits, and man-made fill—overlie most of the bedrock in the Sitka area. The Indian River, Cascade Creek, Sawmill Creek, Swan Lake, Blue Lake, and an unnamed lagoon on Japonski Island are the principal surface-water bodies in the Sitka area. Ground water on Japonski Island is found within surficial deposits and bedrock. The city of Sitka and the Federal Aviation Administration facility on Japonski Island obtain drinking water from Blue Lake. Other surface-water bodies and ground water may provide alternative drinking-water sources.

INTRODUCTION

The Federal Aviation Administration (FAA) owns and (or) operates airway support and navigational facilities throughout Alaska. At many of these sites, fuels and potentially hazardous materials such as solvents, polychlorinated biphenyls, and pesticides may have been used and (or) disposed of. To determine if environmentally hazardous materials have been spilled or disposed of at the sites, the FAA is conducting environmental studies mandated under the Comprehensive Environmental Response, Compensation, and Liability Act and the Resource Conservation and Recovery Act. To complete these more comprehensive environmental studies, the FAA requires information on the hydrology and geology of areas surrounding the sites. This report, the product of compilation, review, and summary of existing hydrologic and geologic data by the U.S. Geological Survey, in cooperation with the FAA, provides such information for the FAA facility and nearby areas at Sitka, Alaska. Also presented in this report are brief descriptions of FAA facility history and the physical setting of the Sitka area.

BACKGROUND

Location

The Sitka FAA facility is on Japonski Island in southeast Alaska (fig. 1) at lat 57°03' N., long 135°25' W., about 150 km southwest of Juneau and about 950 km southeast of Anchorage. Japonski Island is in Sitka Sound about 0.8 km west of the city of Sitka which is on Baranof Island. At the greatest width, Japonski Island is about 1.1 km wide, and at the greatest length, is about 2.3 km long. The City of Sitka is in the Baranof Mountains, a rugged, asymmetric mountain range having a steep eastern slope and a more gradual southwest slope (Wahrhaftig, 1965). The Sitka area, as referenced in this report, includes the city of Sitka and Japonski Island.

Facility History

The FAA has had a facility on Japonski Island near Sitka since 1964. The FAA operates a flight service station and navigational and communication aids. The State of Alaska maintains the runway. A detailed account of FAA owned, leased, or transferred properties near Sitka and a listing of suspected sources of contamination near these properties can be found in an environmental compliance investigation report by Ecology and Environment, Inc. (1993).

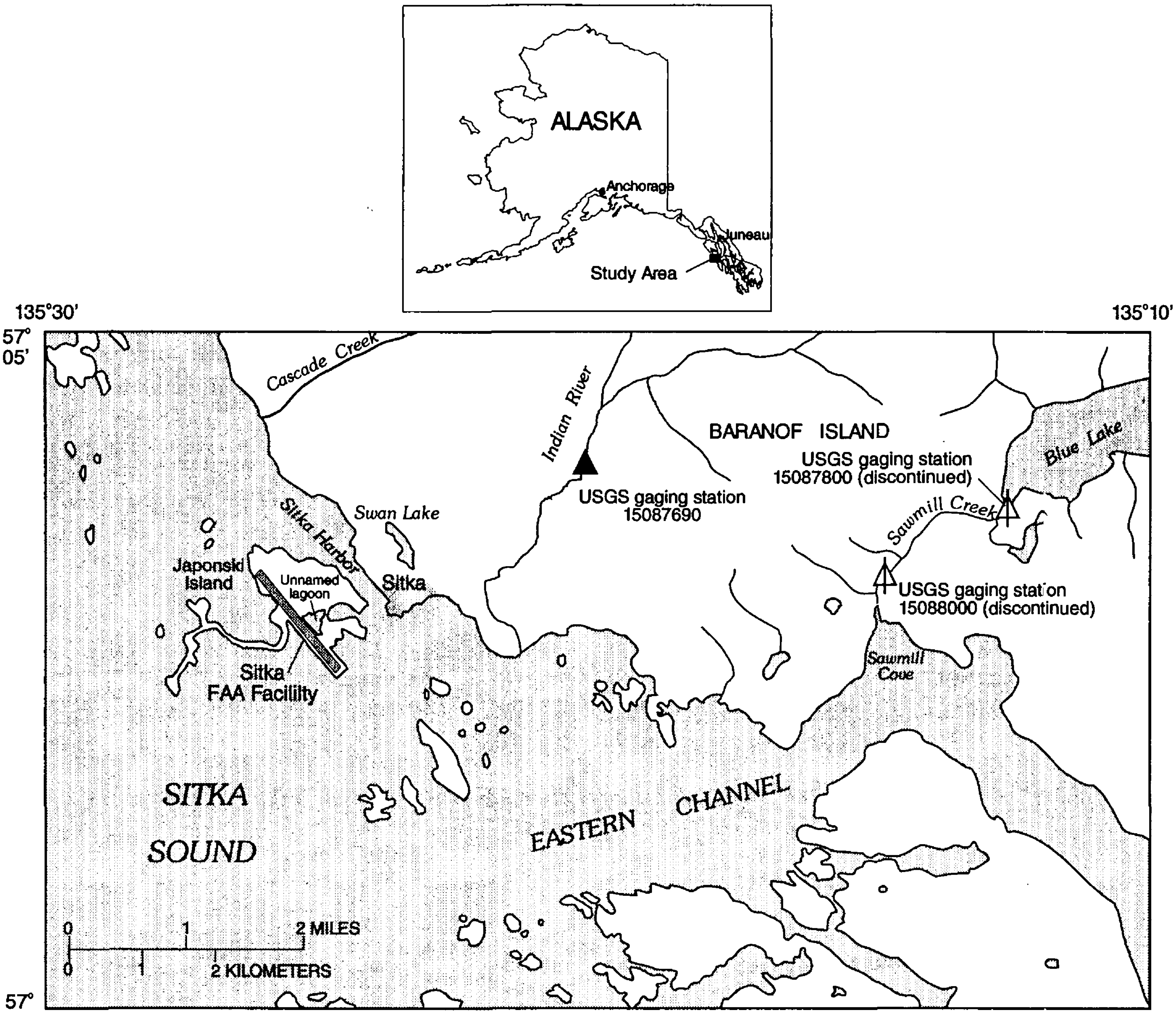
PHYSICAL SETTING

Climate

Sitka has a maritime climate characterized by small temperature variations, high humidity, abundant precipitation, wet, cool summers and relatively mild winters (Hartman and Johnson, 1984). The mean annual temperature recorded at the Sitka FAA facility for the period 1948-87 is 6.9°C. Temperatures range from an August mean maximum of 16.7°C to a January mean minimum of -1.5°C (Leslie, 1989). Mean annual precipitation is about 2,200 mm; about 1,030 mm of snow falls annually (Leslie, 1989). Mean monthly and annual temperature, precipitation, and snowfall for Sitka are summarized in table 1.

Table 1. Mean monthly and annual temperature, precipitation, and snowfall, 1948-87, Sitka, Alaska.
[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (°C)													
Mean maximum	3.2	4.5	5.9	8.5	11.8	14.2	16.1	16.7	14.6	10.2	6.2	3.9	9.7
	(Record maximum 31.1°C, July 1976)												
Mean minimum	-1.5	-0.6	1.9	1.9	5.0	8.1	10.5	10.9	8.7	5.2	1.6	-0.3	4.2
	(Record minimum -18.3°C, February 1948)												
Mean	0.8	1.9	3.1	5.3	8.4	11.1	13.3	13.8	11.7	7.7	3.9	1.8	6.9
Precipitation, in millimeters of moisture													
	185	157	152	131	122	94.2	112	176	272.3	348	239	217	Total 2,200
Snowfall, in millimeters													
	252	216	198	43.2	2.5	0.0	0.0	0.0	0.0	5.1	73.7	244	Total 1,030



Base from U.S.Geological Survey, Sitka (A-4, A-5), Alaska, 1:63,360, 1951.

Figure 1. Location of Sitka, Alaska and the Federal Aviation Administration facility.

Vegetation

Vegetation near Sitka consists primarily of coastal western hemlock-Sitka spruce forest, characterized by an overstory of Sitka spruce, western hemlock, and Alaska yellow cedar and an understory of ferns, lichens, and mosses (Selkregg, 1976; Viereck and Little, 1972). Expanses of subtidal wetlands exist in numerous places on Japonski Island, including the area surrounding the FAA facility runway. Wetland vegetation consists of silverweed, hairgrass, yarrow, buttercup, and a variety of sedges. The area is part of the Tongass National Forest.

GEOLOGY

Bedrock Geology

The bedrock in the Sitka area consists of graywacke, slate, and conglomerate of late Jurassic to early Cretaceous age (Yehle, 1974; Berg and Gehrels, 1992). In some areas, these rocks are intruded by felsic dikes. Bedrock exposures are common in tidal areas where wave action has eroded the overlying surficial material (Yehle, 1974). Depth to bedrock ranges from 1.5 m to greater than 9 m below the land surface (Yehle, 1974). The general topography of the area suggests a land emergence ranging from 15 to 250 m above sea level (Yehle, 1974). The uplift rate in Sitka is about 0.002 m/yr (Yehle, 1974).

Surficial Geology and Soils

With the exception of areas subjected to tidal influences, surficial deposits of Quaternary age overlie most of the bedrock in the Sitka area (Yehle, 1974). Seven distinct units identified on Japonski Island were drift, volcanic ash, muskeg, elevated delta and shore deposits, alluvial deposits, modern beach deposits, and man-made fill (Yehle, 1974).

The drift is mostly till, and consists of gravel, cobbles, and boulders, in a matrix of silt, sand, and clay (Yehle, 1974). The till deposits near Sitka are about 3 m thick and were deposited during Quaternary glaciation of the area. Volcanic ash deposits are and reddish-yellow in color and consist of silt, sand, minor amounts of clay-size particles, and lapilli. The volcanic ash was erupted from Mt. Edgecumbe on Kruzof Island, about 25 km to the east, and nearby volcanoes on Baranof Island. The ash deposits range from 1.5 to 3.4 m in thickness (Yehle, 1974). Muskeg deposits consist of partially decomposed organic material and peat. These deposits occupy lowland areas and may be as much as 9 m thick. Elevated delta and shore deposits consist of loose, well-bedded sandy gravel found in delta zones and along shorelines on Japonski Island. Delta and shore deposits range in thickness from 1.5 to 6 m (Yehle, 1974). Alluvial deposits consist of well-sorted sandy gravel and some cobbles. These deposits are found along streams on Japonski Island, where the thickness ranges from 2.5 to 4.6 m (Yehle, 1974). Modern beach deposits consist of various mixtures of gravel, cobbles, sand, and boulders, ranging from 1.5 to 4.5 m in thickness. The distribution of modern beach deposits is widespread in the Sitka area except along the southwestern edge of Japonski Island. Man-made fill consists of sand, gravel, till, blocks of bedrock, muskeg, and volcanic ash. These deposits surround the runway and all other FAA facilities on Japonski Island and may be as much as 20 m thick (Yehle, 1974).

The soils of the Sitka area are similar to those found throughout southeast Alaska and are of two principal types: soils formed on volcanic ash parent material and soils found under forests of Sitka spruce and western hemlock (Rieger and others, 1979). Well-drained soils, found on low hills near Sitka, develop on thick deposits of sandy and cindery volcanic ash (Rieger and others, 1979). Loamy soils are found under forested areas near the Sitka FAA facility and are characterized by a thin, gray surface layer over thick, black to brown subsurface layers (Rieger and others, 1979). The Sitka area is free of permafrost (Ferrians, 1965).

Earthquakes

The Sitka area lies within the circum-Pacific seismic belt, a region of earthquake activity that rims the north Pacific Ocean. Southeast Alaska is cut by the Chatham Strait Fault, the Fairweather Fault, and numerous smaller faults. In recent years, several earthquakes with Richter scale magnitudes greater than 7 have been recorded along these fault systems (Brower and others, 1977; Stephens and others, 1986).

During the period 1899 to 1972, several earthquakes with Richter magnitudes of 5 or greater have been recorded within 160 km of Sitka (Yehle, 1974). Three of the earthquakes had a magnitude between 5 and 6, two were between 6 and 7, and three were greater than 7 (Yehle, 1974). On July 30, 1972, a major earthquake, between 7.1 and 7.6 on the Richter scale, was reported in the area. The epicenter of this earthquake was about 40 km from Sitka and ground motion lasted for about 40 seconds (Yehle, 1974). Damage to Sitka was minor. The average relative displacement of buildings founded on graywacke bedrock was 0.94 cm (Yehle, 1974). It is assumed that earthquakes with magnitudes of 7.6 or greater will occur again in the Sitka area (Yehle, 1974).

Earthquake-induced water waves often develop during major earthquakes (Yehle, 1974). Several earthquake-induced waves ranging from 0.1 to 4.4 m in height have been recorded in the Sitka area (Yehle, 1974). A 4.4-m high wave from the 1964 Alaska earthquake struck the coastline on March 27, 1964 (Yehle, 1974). Analyses of wave heights that might affect the Sitka Airport and the FAA facility were prepared by Dames and Moore (1971). A 100-year maximum wave of 6 m was established for the Sitka coastal area. Waves of this magnitude may reach the FAA facilities which lie near sea level along the perimeter of Japonski Island.

HYDROLOGY

Surface Water

The Indian River, Cascade Creek, Sawmill Creek, Swan Lake, Blue Lake, and an unnamed lagoon on Japonski Island are the principal surface-water bodies in the Sitka area (fig. 1). The mouth of Sawmill Creek is about 7.5 km east of Japonski Island. The creek flows from Blue Lake southwest to Sawmill Cove. Cascade Creek is about 2 km north of the island and flows southwest to Sitka Sound. The Indian River is about 1.2 km to the east of the island and flows southwest to the Eastern Channel. Swan Lake is about 1 km^2 in size and is about 1 km northeast of Japonski Island. Blue Lake is about 5 km^2 in size and is about 6.5 km east of the island. The unnamed lagoon on Japonski Island is about 0.25 km^2 in area and is adjacent to the FAA facility.

Discharge of the Indian River near Sitka was reported by the U.S. Geological Survey (USGS) from 1980 to 1993 at stream-gaging station 15087690, about 1.6 km northeast of the city of Sitka (fig. 1). During periods of intense snowmelt in May, mean monthly discharge was about 3.1 m^3/s;

during periods of heavy rainfall in October, mean monthly discharge was 5.4 m^3/s; and during periods of low flow in March and April, mean discharge was about 1.9 m^3/s (table 2) (U.S. Geological Survey, 1994). Annual mean flow is about 3 m^3/s. The Indian River drains an area of about 26 km^2 upstream from the gaging station (U.S. Geological Survey, 1994). Average annual runoff is about 0.1 $(m^3/s)/km^2$ (U.S. Geological Survey, 1994). On September 4, 1990, heavy rain caused a maximum reported discharge of about 160 m^3/s (Jones and Fahl, 1994).

Table 2. Mean monthly flow at stream-gaging station 15087690, the Indian River near Sitka, Alaska ,water years 1980-93

[Values in cubic meters per second]

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean	5.4	3.0	2.9	3.0	2.5	1.9	1.9	3.1	2.4	1.7	2.6	5.1
Maximum	8.3	6.2	5.9	5.2	4.4	3.5	3.1	4.7	4.7	3.1	6.7	8.3
Minimum	2.9	1.1	0.6	1.3	1.0	0.6	1.1	1.5	0.8	0.6	0.8	1.4

From 1920 to 1957, a partial record of the streamflow in Sawmill Creek was collected by the U.S. Geological Survey at discontinued stream-gaging station 15088000 (fig. 1). The creek drains an area of about 100 km^2 upstream from the gaging station. During the months of May and June, mean flow was about 19 m^3/s; from August to November mean flow was about 20 m^3/s; and during low-flow periods in March and April, mean flow was about 4.7 m^3/s (U.S. Geological Survey, 1958). Annual mean flow for the period of record was 13.5 m^3/s (U.S Geological Survey, 1958). On September 8, 1948, heavy rains caused a maximum discharge of 200 m^3/s (Jones and Fahl, 1994). Streamflow data for Cascade Creek do not exist.

The diurnal tide range, the difference in height between mean high water and mean low water on a single day, averages 3 m near Sitka (Brower and others, 1977). The maximum daily tide predicted to occur at Sitka is 3.8 m above sea level. The minimum predicted daily tide is -0.8 m below sea level (Brower and others, 1977).

Floods

The city of Sitka has no known history of significant flooding caused by stream overflow or coastal flooding by storm-surge or tsunami waves (Federal Emergency Management Agency, 1981). However, local drainage can be a problem and may cause flooding in low-lying areas (U.S. Army Corps of Engineers, 1993). Tsunamis caused by the 1964 Alaska earthquake, considered to be the largest waves in recent times, produced no unusual flooding (Yehle, 1974). Flood protection along the coastline near Sitka has been achieved by establishing adequate building foundation elevations and riprapping (Federal Emergency Management Agency, 1981).

Ground Water

Ground water on Japonski Island is found within surficial deposits and bedrock. The glacial and volcanic deposits that cover most of the island are relatively impermeable and yield little or no ground water (Appendix 1). The bedrock on Japonski Island has very low permeability and storage capacity, but it has been extensively fractured and some ground water is present in these openings (Appendix 1). In general, the rocks appear to be more fractured in the eastern part of the island; however, no data are available as to the depth to which these fractures may extend before becoming tightly closed by rock pressure.

In an effort to assess Japonski Island's ground-water potential, a 67-m-deep well was drilled in the southern part of the island in 1942 (Appendix 1). The well was drilled into highly fractured bedrock and at a depth of about 37 m; water rose in the well to ground level. A pump was installed in the well and ran continually for 14 hours at a rate 0.5 L/s. Upon removing the pump, the water again rose to ground level. The concentrations of sodium in the well ranged from 1,050 to 1,800 mg/L (Appendix 1). In general, the possibility of salt-water intrusion into coastal and island aquifers increases with depth and pumping rate (Waller and Tolen, 1962)

DRINKING WATER

Present Drinking-Water Supplies

Blue Lake is about 115 m above sea level and is the principal drinking-water source for the city of Sitka and Japonski Island (Alaska Department of Community and Regional Affairs, 1994). The water from the lake is chlorinated and distributed through a piped system to local residents and businesses (Alaska Department of Community and Regional Affairs, 1994). The current water demand is about 12 million L/d or about 1,400 (L/d)/person (Mark Buggins, Sitka Water and Wastewater, oral commun., 1995). The present capacity of the water system is about 23 million L/d (Mark Buggins, Sitka Water and Wastewater, oral commun., 1995). The Indian River was used in the past and remains available as an emergency drinking-water supply.

The water in Blue Lake was sampled by the U.S. Geological Survey in 1968 and 1976 at discontinued USGS stream-gaging station 15087800, Blue Lake outlet near Sitka (fig. 1; U.S. Geological Survey, 1969 and 1977). Water properties and concentrations of major ions were within current U.S. Environmental Protection Agency (USEPA) and the State of Alaska Department of Environmental Conservation (ADEC) drinking-water regulations (table 3; Appendix 2) (Salvato, 1992).

Table 3. Selected water-quality data from Blue Lake at outlet near Sitka, Alaska (USGS gaging station No. 15087800), water years 1968, 1976

Constituent (or property)	USEPA Drinking-water limit (mg/L)	Concentrations in Blue Lake (mg/L)
Chloride (Cl)	250	1.9 - 4.0
Iron (dissolved; Fe)	0.3	0.02
Sulfate (SO_4)	250	0.0 - 3.7
Fluoride (F)	2	<0.1
Lead (Pb)	0.005	0.004
Total dissolved solids	500	19 - 31
pH (units)	6.5 - 8.5	6.6 - 6.8

Alternative Drinking-Water Sources

Drinking-water alternatives for the FAA facility and the city of Sitka include the Indian River, Cascade Creek, Sawmill Creek, Swan Lake, the unnamed lagoon on Japonski Island, and, to a lesser extent, ground water. The ground water near Sitka was sampled by the U.S. Geological Survey in June 1967 (table 4; Appendix 2), but the exact locations of wells are unknown. With the exception of iron, analyses indicated that major ions and other constituents were within current drinking-water regulations (U.S. Geological Survey, 1968).

The Indian River and Sawmill Creek represent abundant sources of drinking water for the Sitka area. During months of low discharge, mean flow of the Indian River, recorded at USGS stream-gaging station 15087690, is about 1.9 m^3/s (table 2; U.S. Geological Survey, 1958 and 1994) and mean flow of Sawmill Creek, recorded at USGS stream-gaging station 15088000, is about 4.7 m^3/s. This is equivalent to about 200 to 400 million L/d and is far greater than the estimated city water use of 12 million L/d.

The water in the Indian River, Cascade Creek, Sawmill Creek, and Swan Lake was sampled by the U.S. Geological Survey during various years from 1949 to 1982 (Appendix 2). With the exception of lead and iron in a sample taken from Cascade Creek, major ions, dissolved metals, nutrients, and water properties were within current USEPA and ADEC drinking-water regulations (table 4). No water-quality data are available for the unnamed lagoon on Japonski Island.

Table 4. Selected water-quality data for alternative drinking-water sources near Sitka, Alaska
[—, no data available]

Constituent (or property)	Concentrations in ground water (mg/L) 1968	Concentration in the Indian River (mg/L) 1967-82	Concentration in Sawmill Creek (mg/L) 1949-58	Concentration in Cascade Creek (mg/L) 1955-76	Concentrations in Swan Lake (mg/L) 1968
Chloride (Cl)	3.5-27	2.8-3.5	1.0-4.0	2.6-6.5	8.0
Iron (total Fe)	0.02-4.7	0.02-0.03	0.0-0.08	0.04-0.94	----
Sulfate (SO_4)	2.0-8.0	0.0-6.0	0.0-5.0	0.0-3.6	4.2
Fluoride (F)	0.0	0.0	0.0-0.2	0.0-0.2	0.1
Lead (Pb)	----	----	----	0.0-0.009	----
Total dissolved solids	19-152	24-26	18-26	19-33	38
pH (units)	6.8-7.2	6.8-7.0	5.9-7.0	6.5-7.0	6.7

SUMMARY

Sitka and nearby Japonski Island are in southeast Alaska about 150 km southwest of Juneau. They lie in the maritime climate zone, characterized by cool summers and mild winters. Vegetation consists primarily of coastal western hemlock-Sitka spruce forest. The bedrock in the area consists of graywacke, slate, and conglomerate of late Jurassic to early Cretaceous age. Surficial deposits of Quaternary age include drift, volcanic ash, muskeg, elevated delta and shore deposits, alluvial deposits, modern beach deposits, and man-made fill. The Indian River, Cascade Creek, Sawmill Creek, Swan Lake, Blue Lake, and an unnamed lagoon on Japonski Island are the principal surface-water bodies near Sitka. Ground water on Japonski Island is found within surficial deposits and bedrock. The city of Sitka and the FAA facility on Japonski Island obtain drinking water from Blue Lake. Other surface-water bodies and ground water may be alternative drinking-water sources. Earthquake activity presents a potential hazard for the local area.

REFERENCES CITED

Alaska Department of Community and Regional Affairs, 1994, Sitka: Alaska Department of Community and Regional Affairs Community computer data base--Sitka, 6 p.

Alaska Department of Environmental Conservation (ADEC), 1995, Alaska water-quality standards 18 AAC 70: Alaska Department of Environmental Conservation, Water-quality management section, Juneau, AK, 47 p.

Berg, H.C., and Gehrels, G.E., 1992, Geologic map of Southeastern Alaska: U.S. Geological Survey Miscellaneous Investigations Series I-1867, 1 sheet and 24 p., scale: 1:600,000.

Brower, W.A., Searby, H.W., and Wise J.L., 1977, Climatic atlas, The outer continental shelf waters and coastal regions of Alaska, volume 1: University of Alaska Anchorage, Arctic Environmental Information Center, 439 p.

Dames and Moore, 1971, Runway extension study report for Sitka Airport--Feasibility evaluation of subsurface conditions and physical environmental factors for proposed airport runway extension, Sitka Alaska: Alaska State Division of Aviation, 35 p.

Ecology and Environment, Inc., 1993, Environmental Compliance Investigation Report (ECRI), Sitka FAA station, Sitka Alaska: Anchorage [Copy available from the Environmental Compliance Section, AAL-465, Federal Aviation Administration, Alaskan Regional Office, Anchorage, AK], variously paged.

Federal Emergency Management Agency, 1981, Flood insurance study--City and Borough of Sitka, Alaska: Federal Emergency Management Agency report, 23 p.

Ferrians, O.J., Jr., 1965, Permafrost map of Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-445, 1 sheet, scale 1:250,000.

Hartman, C.W., and Johnson, P.R., 1984, Environmental atlas of Alaska: University of Alaska Fairbanks, Institute of Water Resources/Engineering Experiment Station, 95 p.

Jones, S.H., and Fahl, C.B., 1994, Magnitude and frequency of floods in Alaska and conterminous basins of Canada: U.S. Geological Survey Water-Resources Investigations Report 93-4179, 122 p., 2 pl.

Leslie, L.D., 1989, Alaska climate summaries (2nd ed.): University of Alaska Anchorage, Arctic Environmental Information and Data Center, Alaska Climate Center Technical Note 5, variously paged.

Rieger, Samuel, Schoephorster, D.B., and Furbush, C.E., 1979, Exploratory soil survey of Alaska: Soil Conservation Service report, 213 p.

Salvato, J.A., 1992, Environmental engineering and sanitation, (4th ed.): Toronto, Canada, John Wiley and Sons, Inc., 1418 p.

Selkregg, L., 1976, Alaska regional profiles--Southeast Region: Anchorage, University of Alaska, Arctic Environmental Information and Data Center, 234 p.

Stephens, C.D., Fogleman, K.A., Lahr, J.C., and Page, R.A., 1986, Seismicity in southern Alaska, *in* Geologic studies in Alaska: U.S. Geological Survey Circular 978, p. 81-85.

U.S. Army Corps of Engineers, 1993, Flood hazard data, Alaska communities, Alaska: U.S. Army Corps of Engineers, 335 p.

U.S. Geological Survey, 1958, Quantity and quality of surface waters of Alaska, water year 1957: U.S. Geological Survey Water-Supply Paper 1500.

_____1967, Quality of surface waters of Alaska, water year 1966: U.S. Geological Survey Water-Supply Paper 1996.

_____1968, Quality of surface waters of Alaska, water year 1967: U.S. Geological Survey Water-Supply Paper 2016.

_____1969, Quality of surface waters of Alaska, water year 1968: U.S. Geological Survey Water-Supply Paper 2150.

_____1977, Water resources data for Alaska, water year 1976: U.S. Geological Survey Water-Data Report AK-76-1.

_____1983, Water resources data for Alaska, water year 1982: U.S. Geological Survey Water-Data Report AK-82-1.

_____1994, Water resources data for Alaska, water year 1993: U.S. Geological Survey Water-Data Report AK-93-1, 373 p.

Viereck, L.A, and Little, E.L., 1972, Alaska trees and shrubs: U.S. Department of Agriculture, Agriculture Handbook No. 410, 265 p.

Wahrhaftig, C., 1965, Physiographic divisions of Alaska: U.S. Geological Survey Professional Paper 482, 52 p.

Waller, R.M., and Tolen, D.A., 1962, Data on ground-water exploration and development in southeastern Alaska: U.S. Geological Survey Hydrological Data Report 19, 15 p.

Yehle, L.A., 1974, Reconnaissance engineering geology of Sitka and vicinity, Alaska, with emphasis on evaluation of earthquake and other geologic hazards: U.S. Geological Survey Open File Report 74-53, 104 p.

APPENDIX 1

Text of a 1942 letter to the Navy regarding availability
of ground water on Japonski Island

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON

Memorandum concerning the occurrence of ground water on Japonski Island, southeastern Alaska

This memorandum relates to a request dated September 5, 1942 from Captain A. J. Isbell, Commanding Officer, Naval Air Station, Sitka, Alaska, to the Geological Survey and an identical request dated August 21, 1942 to the Bureau of Reclamation. The request sent to the Bureau of Reclamation was referred to the Geological Survey for reply.

It is understood that the U. S. Navy desires to obtain a supply of 1,000,000 gallons of water daily from wells on Japonski Island, but will develop as much water as possible for emergency use even if it is much less than 1,000,000 gallons daily. Mr. J. C. Reed, Alaskan Branch, Geological Survey, made a brief investigation of the geology and occurrence of ground water on Japonski Island. Mr. Reed transmitted his findings in the form of a memorandum to the Director of the Geological Survey and submitted a copy of the memorandum to the Commanding Officer at Sitka, with the understanding that owing to the urgent need for the information the material was being released without prior approval by the Director of the Geological Survey. When Mr. Reed returned to Washington he conferred with geologists of the Water Resources Branch of the Geological Survey, and the basic geologic and hydrologic data were carefully studied. The following statement was prepared jointly by the two branches:

The available data show that in general the bedrock on Japonski Island consists of rather dense hard rock that has a northwesterly strike and dips about 70 degrees to the southwest, but in a few localities the rock dips steeply toward the northeast. The bedrock has a very low permeability and storage capacity, but it has been fractured rather extensively and some ground water occurs in the openings formed by the fractures. A zone of relatively intensely fractured rock occurs in the eastern part of the island and trends approximately north. In most places on the island the bedrock is overlain by thin glacial deposits which in some places are overlain in turn by volcanic deposits. The glacial and volcanic deposits are relatively impermeable and will yield little or no ground water.

The geologic structure indicates that it is very unlikely that any ground water reaches Japonski Island as underflow from the mainland (Baranof Island). Hence any ground water that occurs on Japonski Island is derived from rainfall penetration. Inasmuch as Japonski Island is relatively small, and the glacial and volcanic deposits are relatively impermeable which would hinder recharge, it appears that the development of a continuous supply of 1,000,000 gallons daily, or even of a considerably smaller continuous supply, from wells is not practicable. Wells in the bedrock will not yield any large supplies unless large or very numerous fractures are encountered, which seems unlikely. However, it may be possible to develop small supplies of potable water, or fairly large supplies from a considerable number of wells for emergency use during short periods.

At the time of Mr. Reed's visit to the island, the Navy was drilling a 2-inch test hole, which on October 3, 1942, had reached the depth of 220 feet. It was reported that water was encountered at a depth of 120 feet and that the water rose in the well to the land surface, about 20 (?) feet above sea level. It was understood that the well was to be drilled deeper. The well was being drilled with a diamond-core outfit and salt water was being used for drilling fluid. On October 3 and 4 a pumping test was run, by use of an airlift, for 14½ hours, and it was found that the well yielded about 8 gallons a minute, but this quantity may not be the maximum capacity of the well. When the airlift was shut off the water level in the well quickly rose to about its former level. Samples of water yielded by the well were collected at various times during the pumping test. The samples were tested in a laboratory at the Naval Air Station for approximate salt content. The results of these analyses show that the salt content of the samples varied considerably (from 62 to 105 grains of salt per gallon, or from about 1,050 to 1,800 parts per million). All the samples contained a large content of salt. As salt water was used as drilling fluid, it is possible that the salt content may not be representative of the water that occurs naturally in the rocks.

On many small islands underlain by permeable rocks that are freely connected with the ocean, it is possible to determine the approximate depth to salt water by knowing the elevation of the water table. Ordinarily there is about 40 feet of fresh water below sea level for every foot of fresh water above sea level. On Japonski Island this principle may not apply because the bedrock probably becomes less fractured with depth.

In order to determine the best localities for ground-water development it is desirable to drill several shallow test holes in the zone of fractured rock on the east side of the island and in other areas which may also be underlain by intensely fractured rocks. The diamond-core outfit that is already on the island will be satisfactory for this purpose, but the 2-inch wells will not yield as much water as wells of larger diameter, such as would be drilled by the churn or cable tool method. For production wells, diameters of 6 to 10 inches are recommended. It is recommended that the wells be drilled no deeper than about 300 feet. The drilling fluid should be fresh water in order to avoid contamination of the ground water.

Careful records should be made of the character of the rocks at successive depths so as to obtain information as to the intensity of fracturing and the depths at which the fracturing occurs. As soon as water is encountered, a sample of the water should be collected and tested for salt content. The well should be tested for about 15 minutes for yield, by bailing or airlift, at approximately the following depths, in feet, below the level at which the first water was encountered: 25, 50, 100, 150, 200, 250, and 300 feet. Samples of water should be collected near the end of each bailing or pumping test. When the well is completed a pumping test of about one hour duration should be run, and tests of longer duration may be desirable on some wells. In the final pumping tests samples of water should be collected soon after the test has been started and again at the end of the test. In testing each well for yield the water level in the well should be measured before pumping is started and the rate of recovery of the water level should be determined by making a series of measurements after pumping has been stopped. The rate of recovery of the water level will indicate the relative permeability of the water-bearing material. If the water level does not recover to the approximate level it stood before pumping started, it would indicate that the ground-water reservoir is restricted. It is also recommended that the altitudes of the water levels in the wells be determined, after the well has been idle for several hours, in order to determine the general height of the water table.

If the test holes produce reasonably favorable results, production wells may be drilled at places where the yield of the test wells was relatively large and the salt content of the water relatively low. The wells should be placed as far from the shore as practicable and where the water table is relatively high. The production wells should be drilled by the churn or cable tool method and should be at least 6 inches in diameter.

The Geological Survey will be glad to help interpret the data obtained in the test drilling. It is suggested that a record of each well be transmitted to the Geological Survey as soon as it is practicable. Locations may be described by giving the distance and direction from the northwest corner of the Maintenance Building on Japonski Island. Samples of water may also be sent to the Geological Survey for chemical analysis. It is desirable that field tests of the salt content of the same samples be run for comparison with the analyses to be made in the laboratory of the Geological Survey.

October 22, 1942.

For Navy

JCR:RRB:OEM:gc

John C. Reed
Senior Geologist

Robert R. Bennett
Assistant Geologist

APPENDIX 2

Water-quality data for surface water near Sitka, Alaska

LOCAL WELL NUMBER	PRIMARY USE OF WATER	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WELL CONSTRUCTED	OWNER	ASSIGNOR OF OTHER IDENTIFIER	OTHER IDENTIFIER	TYPE OF LOG AVAILABLE
CD05206224 1S	M	--	--	--	PUBLIC DOMAIN	--	--	-
CD05506624ADCB1S	R	--	--	--	BARANOF HOT SPRG	--	--	-
CD05806317CCCA1S	M	--	--	--	PUBLIC DOMAIN	--	--	-
CD05806317CCCA2S	M	--	--	--	PUBLIC DOMAIN	--	--	-

SOUTHEASTERN ALASKA

MISCELLANEOUS GROUND-WATER ANALYSES FOR SOUTHEASTERN ALASKA—Continued

CHEMICAL ANALYSES, IN MILLIGRAMS PER LITER, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

LATITUDE AND LONGITUDE	DATE	SILICA (SiO_2)	IRON (FE)	CAL-CIUM (CA)	MAGNE-SIUM (MG)	SODIUM (NA)	POTAS-SIUM (K)	BICAR-BONATE (HCO_3)	CAR-BONATE (CO_3)	SULFATE (SO_4)
GREATER SITKA BOROUGH										
57°03' 135°19'	June 15, 1967	2.8	.02	4.5	.5	1.2	.3	13	0	6.0
57°04' 135°22'	June 15......	14	4.7	21	5.0	23	1.3	98	0	8.0
57°04'42" 135°20'07"	June 15......	3.2	.13	3.4	.4	1.3	.4	9	0	2.0

CHLORIDE (CL)	FLUORIDE (F)	NITRATE (NO_3)	DIS-SOLVED SOLIDS	HARDNESS (CA, MG)	NON-CAR-BONATE HARDNESS	SPECIFIC CON-DUCTANCE (MICRO-MHOS)	PH	COLOR
3.5	.0	.5	26	13	2	43	7.1	3
27	.0	.2	152	74	0	246	7.2	10
3.5	.0	.4	19	10	3	29	6.8	10

STATION NUMBER	DATE	TIME	LAT-I-TUDE	LONG-I-TUDE	LOCAL IDENT-I-FIER	MEDIUM CODE	SAMPLE TYPE	RECORD NUMBER
15087650	02-07-55	--	57 04 27 N	135 21 48 W	CASCADE C AT SITKA AK	9	9	95500005
15087650	05-05-58	--	57 04 27 N	135 21 48 W	CASCADE C AT SITKA AK	9	9	95800003
15087650	12-20-60	--	57 04 27 N	135 21 48 W	CASCADE C AT SITKA AK	9	9	96100009
15087650	06-23-68	1350	57 04 27 N	135 21 48 W	CASCADE C AT SITKA AK	9	9	96800129
15087650	12-12-68	1100	57 04 27 N	135 21 48 W	CASCADE C AT SITKA AK	9	9	96900053
15087650	05-27-76	1100	57 04 27 N	135 21 48 W	CASCADE C AT SITKA AK	9	9	97600053
15087680	06-22-68	2100	57 03 20 N	135 20 12 W	SWAN LK AT SITKA AK	9	9	96800130
15087690	10-12-82	1630	57 04 01 N	135 17 42 W	INDIAN R NR SITKA AK	9	9	98300036
15087700	06-15-67	--	57 03 13 N	135 18 57 W	INDIAN R AT SITKA AK	9	9	96700082
15087700	06-23-68	1330	57 03 13 N	135 18 57 W	INDIAN R AT SITKA AK	9	9	96800131
15087800	06-23-68	1250	57 03 48 N	135 12 02 W	BLUE LK AT OUTLET NR SITKA	9	9	96800132
15087800	06-27-68	--	57 03 48 N	135 12 02 W	BLUE LK AT OUTLET NR SITKA	9	9	96800133
15087800	05-27-76	1400	57 03 48 N	135 12 02 W	BLUE LK AT OUTLET NR SITKA	9	9	97600054
15088000	08-10-49	--	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	94900053
15088000	01-20-54	1400	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95400001
15088000	05-04-54	1320	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95400002
15088000	09-01-54	0930	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95400003
15088000	11-16-54	1100	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95500006
15088000	02-07-55	--	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95500007
15088000	06-19-55	1415	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95500008
15088000	08-29-55	1330	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95500009
15088000	02-03-56	1450	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95600015
15088000	10-30-56	--	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95700004
15088000	01-24-57	--	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95700005
15088000	02-20-57	--	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95700006
15088000	05-20-57	--	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95700007
15088000	09-22-57	--	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95700008
15088000	02-07-58	--	57 03 05 N	135 13 40 W	SAWMILL C NR SITKA AK	9	9	95800004

STATION NUMBER	DATE	TEMPER-ATURE WATER (DEG C) (00010)	COL-LECTING SAMPLE (CODE NUMBER) (00027)	ANA-LYZING SAMPLE (CODE NUMBER) (00028)	SURFACE AREA (SQ MI) (00049)	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	COLOR (PLAT-INUM-COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STAND-ARD UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)
15087650	02-07-55	--	--	--	--	--	5	42	6.8	3.8
15087650	05-05-58	--	--	--	--	--	10	28	6.8	2.5
15087650	12-20-60	--	--	--	--	--	10	37	6.8	3.0
15087650	06-23-68	8.0	--	--	--	--	5	57	7.0	4.0
15087650	12-12-68	--	--	--	--	--	5	52	6.5	9.1
15087650	05-27-76	--	9815	--	--	--	7	--	--	--
15087680	06-22-68	15.5	--	--	--	--	45	75	6.7	7.0
15087690	10-12-82	9.5	1028	80020	--	2650	--	21	--	--
15087700	06-15-67	6.5	--	--	--	--	5	43	7.1	1.7
15087700	06-23-68	8.0	--	--	--	30	0	46	6.8	5.1
15087800	06-23-68	10.5	--	--	--	--	5	36	6.8	3.6
15087800	06-27-68	--	--	--	--	--	0	34	6.6	5.6
15087800	05-27-76	--	9815	--	--	--	3	45	--	--
15088000	08-10-49	--	--	--	39	942	--	32	6.0	24
15088000	01-20-54	0.5	--	--	39	--	5	37	6.0	22
15088000	05-04-54	8.0	--	--	39	--	--	39	6.8	4.6
15088000	09-01-54	9.5	--	--	39	--	--	27	6.9	2.6
15088000	11-16-54	6.0	--	--	39	--	--	36	6.8	3.8
15088000	02-07-55	--	--	--	39	--	10	35	6.4	8.9
15088000	06-19-55	6.5	--	--	39	--	--	37	7.0	2.4
15088000	08-29-55	--	--	--	39	686	--	45	5.9	28
15088000	02-03-56	--	--	--	39	34	--	42	6.4	8.9
15088000	10-30-56	5.0	--	--	39	--	5	35	6.1	13
15088000	01-24-57	0.0	--	--	39	62	0	48	6.7	4.8
15088000	02-20-57	--	--	--	39	--	5	40	7.0	2.4
15088000	05-20-57	4.5	--	--	39	--	--	44	6.4	7.0
15088000	09-22-57	--	--	--	39	352	5	27	6.0	16
15088000	02-07-58	--	--	--	39	--	0	41	6.9	3.4

STATION NUMBER	DATE	ALKA-LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	BICAR-BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	CAR-BONATE WATER WH FET FIELD MG/L AS CO3 (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	NITRO-GEN, NITRATE TOTAL (MG/L AS N) (00620)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N) (00630)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	PHOS-PHATE, TOTAL (MG/L AS PO4) (00650)	PHOS-PHATE, ORTHO, DIS-SOLVED (MG/L AS PO4) (00660)
15087650	02-07-55	12	15	--	0.070	--	--	--	--	--
15087650	05-05-58	8	10	--	0.090	--	--	--	--	--
15087650	12-20-60	10	12	0	0.050	--	--	--	0.03	--
15087650	06-23-68	21	25	0	0.00	--	--	--	--	--
15087650	12-12-68	15	18	0	0.00	--	--	--	--	--
15087650	05-27-76	8	10	--	--	0.070	0.070	0.070	--	0.0
15087680	06-22-68	18	22	0	0.020	--	--	--	--	--
15087690	10-12-82	--	--	--	--	--	--	--	--	--
15087700	06-15-67	11	13	0	0.110	--	--	--	--	--
15087700	06-23-68	16	20	0	0.070	--	--	--	--	--
15087800	06-23-68	11	14	0	0.050	--	--	--	--	--
15087800	06-27-68	11	14	0	0.090	--	--	--	--	--
15087800	05-27-76	14	17	--	--	0.840	0.840	0.840	--	0.0
15088000	08-10-49	12	15	--	0.070	--	--	--	--	--
15088000	01-20-54	11	14	--	0.020	--	--	--	--	--
15088000	05-04-54	15	18	--	0.070	--	--	--	--	--
15088000	09-01-54	11	13	--	0.050	--	--	--	--	--
15088000	11-16-54	12	15	--	0.020	--	--	--	--	--
15088000	02-07-55	11	14	--	0.090	--	--	--	--	--
15088000	06-19-55	12	15	--	0.020	--	--	--	--	--
15088000	08-29-55	11	14	--	0.020	--	--	--	--	--
15088000	02-03-56	11	14	--	0.020	--	--	--	--	--
15088000	10-30-56	8	10	--	0.020	--	--	--	--	--
15088000	01-24-57	12	15	--	0.110	--	--	--	--	--
15088000	02-20-57	12	15	--	0.110	--	--	--	--	--
15088000	05-20-57	9	11	--	0.00	--	--	--	--	--
15088000	09-22-57	8	10	--	0.050	--	--	--	--	--
15088000	02-07-58	14	17	--	0.050	--	--	--	--	--

STATION NUMBER	DATE	PHOS-PHORUS ORTHO, DIS-SOLVED (MG/L AS P) (00671)	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	HARD-NESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	SODIUM+ POTAS-SIUM DIS-SOLVED (MG/L AS NA) (00933)
15087650	02-07-55	--	13	0	4.1	0.60	3.2	0.4	35	--
15087650	05-05-58	--	10	2	2.0	1.2	2.2	0.3	33	--
15087650	12-20-60	--	13	3	4.0	0.70	2.7	0.3	31	--
15087650	06-23-68	--	18	0	6.1	0.70	2.3	0.2	22	--
15087650	12-12-68	--	18	3	6.0	0.80	3.2	0.3	28	--
15087650	05-27-76	<0.010	10	1	3.2	0.40	2.7	0.4	37	--
15087680	06-22-68	--	18	0	4.8	1.4	6.0	0.6	42	--
15087690	10-12-82	--	--	--	--	--	--	--	--	--
15087700	06-15-67	--	13	2	4.5	0.50	1.2	0.1	16	--
15087700	06-23-68	--	14	0	4.8	0.50	2.0	0.2	24	--
15087800	06-23-68	--	10	0	3.8	0.20	1.4	0.2	22	--
15087800	06-27-68	--	10	0	3.4	0.30	1.4	0.2	23	--
15087800	05-27-76	<0.010	16	2	5.4	0.60	2.3	0.3	24	--
15088000	08-10-49	--	11	0	--	--	--	--	--	3.0
15088000	01-20-54	--	14	2	4.9	0.50	1.4	0.2	17	--
15088000	05-04-54	--	13	0	4.5	0.50	1.5	0.2	19	--
15088000	09-01-54	--	11	1	4.0	0.30	1.5	0.2	22	--
15088000	11-16-54	--	12	0	4.7	0.10	1.3	0.2	19	--
15088000	02-07-55	--	12	1	4.6	0.20	1.6	0.2	21	--
15088000	06-19-55	--	16	5	4.8	0.90	1.2	0.1	14	--
15088000	08-29-55	--	18	6	5.2	1.2	1.0	0.1	11	--
15088000	02-03-56	--	16	4	5.2	0.70	2.0	0.2	21	--
15088000	10-30-56	--	12	4	4.4	0.20	1.2	0.2	17	--
15088000	01-24-57	--	13	1	5.2	0.0	2.3	0.3	27	--
15088000	02-20-57	--	14	2	4.4	0.70	1.7	0.2	21	--
15088000	05-20-57	--	17	8	5.6	0.80	1.2	0.1	13	--
15088000	09-22-57	--	14	6	4.0	1.0	0.90	0.1	12	--
15088000	02-07-58	--	17	3	5.6	0.70	1.2	0.1	13	--

STATION NUMBER	DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	BARIUM, DIS-SOLVED (UG/L AS BA) (01005)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)
15087650	02-07-55	0.30	5.1	2.3	0.10	4.2	--	--	--	--
15087650	05-05-58	0.0	4.0	1.0	0.10	2.8	--	--	--	--
15087650	12-20-60	0.10	6.5	0.0	0.0	3.4	--	--	--	--
15087650	06-23-68	0.0	2.6	3.6	0.0	5.0	--	--	--	--
15087650	12-12-68	0.0	3.9	3.0	0.20	5.2	--	0	--	--
15087650	05-27-76	0.20	4.0	2.4	<0.10	2.4	4	<100	ND	ND
15087680	06-22-68	0.20	8.0	4.2	0.10	2.6	--	--	--	--
15087690	10-12-82	--	--	--	--	--	--	--	--	--
15087700	06-15-67	0.30	3.5	6.0	0.0	2.8	--	--	--	--
15087700	06-23-68	0.0	2.8	0.0	0.0	3.5	--	--	--	--
15087800	06-23-68	0.20	1.9	2.5	0.0	1.5	--	--	--	--
15087800	06-27-68	0.30	2.4	0.0	0.0	1.5	--	--	--	--
15087800	05-27-76	0.10	4.0	3.7	<0.10	2.7	<1	<100	ND	ND
15088000	08-10-49	--	1.5	2.9	--	1.6	--	--	--	--
15088000	01-20-54	0.50	2.8	2.5	0.10	3.5	--	--	--	--
15088000	05-04-54	0.20	3.0	4.3	--	3.1	--	--	--	--
15088000	09-01-54	0.20	1.0	3.8	--	2.5	--	--	--	--
15088000	11-16-54	0.10	2.3	3.4	--	2.3	--	--	--	--
15088000	02-07-55	0.70	2.5	2.6	0.10	2.4	--	--	--	--
15088000	06-19-55	0.50	4.0	2.5	0.20	2.3	--	--	--	--
15088000	08-29-55	0.30	2.0	5.0	0.0	2.2	--	--	--	--
15088000	02-03-56	0.60	4.0	4.0	0.0	2.0	--	--	--	--
15088000	10-30-56	0.50	2.5	2.0	0.0	1.8	--	--	--	--
15088000	01-24-57	0.60	3.0	1.3	0.10	2.3	--	--	--	--
15088000	02-20-57	0.30	2.0	2.5	0.10	2.3	--	--	--	--
15088000	05-20-57	0.20	2.0	5.0	0.0	2.0	--	--	--	--
15088000	09-22-57	0.10	1.0	5.0	0.0	1.5	--	--	--	--
15088000	02-07-58	0.50	1.0	5.0	0.0	2.2	--	--	--	--

STATION NUMBER	DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR) (01034)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	SILVER, DIS-SOLVED (UG/L AS AG) (01075)	STRON-TIUM, DIS-SOLVED (UG/L AS SR) (01080)	ZINC, DIS-SOLVED (UG/L AS ZN) (01090)	LITHIUM DIS-SOLVED (UG/L AS LI) (01130)
15087650	02-07-55	--	--	--	--	--	--	--	--	--
15087650	05-05-58	--	--	--	--	--	--	--	--	--
15087650	12-20-60	--	--	--	--	--	--	--	--	--
15087650	06-23-68	--	--	--	--	--	--	--	--	--
15087650	12-12-68	0	50	--	0	--	0	100	10	0
15087650	05-27-76	--	6	40	9	<10	ND	--	<20	--
15087680	06-22-68	--	--	--	--	--	--	--	--	--
15087690	10-12-82	--	--	--	--	--	--	--	--	--
15087700	06-15-67	--	--	--	--	--	--	--	--	--
15087700	06-23-68	--	--	--	--	--	--	--	--	--
15087800	06-23-68	--	--	--	--	--	--	--	--	--
15087800	06-27-68	--	--	--	--	--	--	--	--	--
15087800	05-27-76	--	<2	20	4	<10	ND	--	ND	--
15088000	08-10-49	--	--	--	--	--	--	--	--	--
15088000	01-20-54	--	--	--	--	--	--	--	--	--
15088000	05-04-54	--	--	--	--	--	--	--	--	--
15088000	09-01-54	--	--	--	--	--	--	--	--	--
15088000	11-16-54	--	--	--	--	--	--	--	--	--
15088000	02-07-55	--	--	--	--	--	--	--	--	--
15088000	06-19-55	--	--	--	--	--	--	--	--	--
15088000	08-29-55	--	--	--	--	--	--	--	--	--
15088000	02-03-56	--	--	--	--	--	--	--	--	--
15088000	10-30-56	--	--	--	--	--	--	--	--	--
15088000	01-24-57	--	--	--	--	--	--	--	--	--
15088000	02-20-57	--	--	--	--	--	--	--	--	--
15088000	05-20-57	--	--	--	--	--	--	--	--	--
15088000	09-22-57	--	--	--	--	--	--	--	--	--
15088000	02-07-58	--	--	--	--	--	--	--	--	--

STATION NUMBER	DATE	SELE-NIUM, DIS-SOLVED (UG/L AS SE) (01145)	METHY-LENE BLUE ACTIVE SUB-STANCE (MG/L) (38260)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER DAY) (70302)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	SED. SUSP. SIEVE DIAM. % FINER THAN 1.00 MM (70335)	SED. SUSP. SIEVE DIAM. % FINER THAN 2.00 MM (70336)	SED. SUSP. FALL DIAM. % FINER THAN .062 MM (70342)	SED. SUSP. FALL DIAM. % FINER THAN .125 MM (70343)
15087650	02-07-55	--	--	28	--	0.04	--	--	--	--
15087650	05-05-58	--	--	19	--	0.02	--	--	--	--
15087650	12-20-60	--	--	24	--	0.03	--	--	--	--
15087650	06-23-68	--	--	33	--	0.04	--	--	--	--
15087650	12-12-68	0	0.0	31	--	0.04	--	--	--	--
15087650	05-27-76	<1	--	21	--	0.03	--	--	--	--
15087680	06-22-68	--	--	38	--	0.05	--	--	--	--
15087690	10-12-82	--	--	--	--	--	96	100	58	68
15087700	06-15-67	--	--	26	--	0.03	--	--	--	--
15087700	06-23-68	--	--	24	1.92	0.03	--	--	--	--
15087800	06-23-68	--	--	19	--	0.02	--	--	--	--
15087800	06-27-68	--	--	17	--	0.02	--	--	--	--
15087800	05-27-76	<1	--	31	--	0.04	--	--	--	--
15088000	08-10-49	--	--	--	--	--	--	--	--	--
15088000	01-20-54	--	--	23	--	0.03	--	--	--	--
15088000	05-04-54	--	--	26	--	0.04	--	--	--	--
15088000	09-01-54	--	--	20	--	0.03	--	--	--	--
15088000	11-16-54	--	--	22	--	0.03	--	--	--	--
15088000	02-07-55	--	--	22	--	0.03	--	--	--	--
15088000	06-19-55	--	--	24	--	0.03	--	--	--	--
15088000	08-29-55	--	--	24	44.2	0.03	--	--	--	--
15088000	02-03-56	--	--	25	2.34	0.03	--	--	--	--
15088000	10-30-56	--	--	18	--	0.02	--	--	--	--
15088000	01-24-57	--	--	23	3.79	0.03	--	--	--	--
15088000	02-20-57	--	--	22	--	0.03	--	--	--	--
15088000	05-20-57	--	--	22	--	0.03	--	--	--	--
15088000	09-22-57	--	--	19	17.7	0.02	--	--	--	--
15088000	02-07-58	--	--	25	--	0.03	--	--	--	--

STATION NUMBER	DATE	SED. SUSP. FALL DIAM. % FINER THAN .250 MM (70344)	SED. SUSP. FALL DIAM. % FINER THAN .500 MM (70345)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	MANGA-NESE (UG/L AS MN) (71883)	IRON (UG/L AS FE) (71885)	ELEV. OF LAND SURFACE DATUM (FT. ABOVE NGVD) (72000)	SEDI-MENT, SUS-PENDED (MG/L) (80154)	SEDI-MENT, DIS-CHARGE, SUS-PENDED (T/DAY) (80155)	DRAIN-AGE AREA (SQ. MI.) (81024)
15087650	02-07-55	--	--	0.30	0	50	--	--	--	--
15087650	05-05-58	--	--	0.40	0	110	--	--	--	--
15087650	12-20-60	--	--	0.20	0	50	--	--	--	--
15087650	06-23-68	--	--	0.0	--	940	--	--	--	--
15087650	12-12-68	--	--	0.0	10	40	--	--	--	--
15087650	05-27-76	--	--	--	--	--	--	--	--	--
15087680	06-22-68	--	--	0.10	--	550	--	--	--	--
15087690	10-12-82	82	93	--	--	--	125	176	1260	10.1
15087700	06-15-67	--	--	0.50	--	20	--	--	--	--
15087700	06-23-68	--	--	0.30	--	30	--	--	--	--
15087800	06-23-68	--	--	0.20	--	210	--	--	--	--
15087800	06-27-68	--	--	0.40	--	--	--	--	--	--
15087800	05-27-76	--	--	--	--	--	--	--	--	--
15088000	08-10-49	--	--	0.30	--	--	4.0	--	--	39.0
15088000	01-20-54	--	--	0.10	--	20	4.0	--	--	39.0
15088000	05-04-54	--	--	0.30	--	70	4.0	--	--	39.0
15088000	09-01-54	--	--	0.20	--	80	4.0	--	--	39.0
15088000	11-16-54	--	--	0.10	--	80	4.0	--	--	39.0
15088000	02-07-55	--	--	0.40	0	40	4.0	--	--	39.0
15088000	06-19-55	--	--	0.10	--	50	4.0	--	--	39.0
15088000	08-29-55	--	--	0.10	--	80	4.0	--	--	39.0
15088000	02-03-56	--	--	0.10	--	50	4.0	--	--	39.0
15088000	10-30-56	--	--	0.10	0	0	4.0	--	--	39.0
15088000	01-24-57	--	--	0.50	0	0	4.0	--	--	39.0
15088000	02-20-57	--	--	0.50	0	60	4.0	--	--	39.0
15088000	05-20-57	--	--	0.0	20	0	4.0	--	--	39.0
15088000	09-22-57	--	--	0.20	10	0	4.0	--	--	39.0
15088000	02-07-58	--	--	0.20	0	0	4.0	--	--	39.0